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Reprinted from JOURNAL OF DAIRY SCIENCE, July, 1956, Vol. XXXIX, No. 7, pages 965-970.

# COMPARISON OF BAKING QUALITY OF FROZEN CONDENSED AND SPRAY-DRIED SKIMMILK

L. V. ROGERS, T. J. MUCHA, AND R. W. BELL

*Eastern Utilization Research Branch, Agricultural Research Service, USDA, Washington, D. C.*

Previous investigations of frozen condensed skimmilk containing 27% solids *(2)* indicated that this product could be satisfactorily used in bread if the milk had received adequate heat treatment prior to freezing. Various amounts of sucrose were added to this 3:1 skimmilk, and although they improved the body of the thawed samples, neither the sugar nor the storage temperature was an important factor in determining the baking quality of the thawed skimmilk. Heat treatment of 82° C. for 30 minutes proved adequate, since samples so heated produced dough and bread of superior characteristics.

In these earlier investigations of the baking quality of frozen condensed skimmilk, the dough quality and loaf volumes were compared with those obtained when commercially produced dried nonfat milk solids, of good baking quality, were included in the bread formula at equivalent levels.

The purpose of the present investigation was to compare the baking quality of frozen condensed skimmilks having a solids ratio higher than 3:1 (27% nonfat milk solids) with that of spray-dried skimmilk obtained from another portion of the same skimmilk. Since it is known that denaturation takes place more rapidly and to a greater extent in frozen milks having a higher solids content than 27% *(1)*, greater destabilization would be expected after a comparable storage period than at the lower solids level.

## METHODS AND MATERIALS

Whole milk was heated to 43° C. and separated. Part of the resultant skimmilk was held at 63° C. for 30 minutes (low-heat treatment), cooled to 49° C., and condensed to 36% solids. A portion of this condensed skimmilk was packaged in 1-l. cans and placed in a storage room at –17° C. The remainder was spray-dried, stored at 4° C., and used as the low-heat–treated skimmilk powder.

The remaining raw skimmilk was held at 82° C. for 30 minutes (high-heat treatment), cooled to 49° C., and condensed to a 4:1 milk-solids ratio. A portion of this skimmilk, which now contained 36% milk solids-not-fat, was withdrawn from the pan, placed in 1-l. cans, and stored at –17° C. Another portion was spray-dried and stored at 4° C. for later use in the baking trials. The skimmilk containing 36% milk solids, which remained in the vacuum pan, was condensed further until a 5:1 solids-ratio product, containing 45% milk solids-not-fat, was obtained. Cans of this product were placed in storage at –17° C. A can of each milk prepared as described was removed periodically over approximately a year from each storage space and the contents were thawed in a water bath at 21° C. After thawing, the cans were opened, their contents were poured into a suitable

Received for publication September 12, 1955.

container, and the physical appearance of the product was noted. After moderate mixing, a portion was reconstituted to 9% solids and used to evaluate flavor and in determining the solubility index expressed as milliliters of sediment per 50 ml. of sample. In determining the latter, a 50-ml. portion was placed in a graduated conical tube and centrifuged at 1,000 r.p.m. for 5 minutes. The maximum desirable sediment in stable milks was considered to be 0.5 ml.

## RESULTS AND DISCUSSION

The day after the condensed skimmilks were prepared, the viscosity values at 22° C., as determined with a MacMichael viscosimeter, were: for skimmilk having a 4:1 solids ratio and a low-heat treatment, 172 cps.; for 4:1 high-heat–treated skimmilk, 480 cps.; and for 5:1 high-heat–treated milk, 28,690 cps. The high-heat treatment caused an increase in the viscosity of the 4:1 milk. This comparison could not be made on 5:1 milks, since no low-heat treatment product containing 45% milk solids-not-fat was prepared. As expected, the high-heat–treated skimmilk had a heated flavor, and a condensed flavor was noted in all of the condensed products.

Since it was desired to obtain destabilized milks for baking purposes, samples were stored 2 months before examination. At this time all thawed samples were heterogeneous and their viscosities could not be determined accurately. They were semi-solid and were described as dry and resembling cold mashed potatoes. In the 4:1 milk there was some whey separation. The flavor of all samples, after reconstituting to 9% total solids, was bland. The 5:1 samples were gritty owing to crystallization of lactose.

At 90 days, the thawed samples were about the same except that they were becoming firmer and the 4:1 samples were also becoming gritty. Free whey was beginning to appear throughout each sample. Sediment content of the reconstituted milks was measured at this examination. It was found that even after storage at –27° C. the 5:1 milk had 12 ml. of sediment per 50 ml. of reconstituted sample. This was more than that found in either the low- or high-heat–treated 4:1 milks. However, it was less than that observed in the 5:1 samples stored at –17° C. The flavor of all milks remained bland and continued so throughout the entire experiment.

At the end of 240 days, the 4:1 samples were becoming pasty, and more wheying-off was observed than in previous examinations. The 5:1 sample that was stored at –17° C. was dry and crumbly; the same milk stored at –27° C. also was crumbly but did not possess the dry appearance of the milk stored at –17° C. The quantity of sediment (10 ml.) from all milks was about the same at this examination.

From the end of the ninth month (270 days) until completion of the experiment (1 year), no particular change was noted that was not observed at the eighth-month examination, except for differences in the quantity of sediment. These were probably due to the rapid rate at which settling occurred after shaking and prior to pouring into the 50-ml. conical centrifuge tubes. The solubility of those milks became less and less as storage time increased. They were in poor physical condition and were wholly undesirable from the beverage standpoint.

In order to compare the baking quality of the variously treated and stored skimmilk samples, experimental baking tests were carried out on the fresh samples and on the stored samples at appropriate time intervals over a period of 1 year.

The flour used in the experimental baking test was an equal mixture of commercially produced bakers' grade patent, spring wheat (Northwestern origin), and winter wheat (Southwestern origin), which were selected to provide a flour mixture corresponding to flour that would be used in commercial bakeries. All other ingredients in the baking formula were also of commercial type and grade. The amounts of various ingredients, considered typical of customary bread formulas, are given below:

| | Parts by weight |
|---|---|
| Flour | 100 |
| Sugar | 5 |
| Salt | 2 |
| Lard | 2 |
| Malted wheat | ½ |
| Yeast food | ¼ |
| Yeast | 2 |
| Nonfat milk solids | 6 |
| Water—variable to give proper dough consistency | |

The straight dough procedure of bread manufacture was followed, and the dough mixing was carried out in a Fleischmann laboratory mixer at time intervals necessary for proper development of the dough. Two dough pieces, each sufficient for a 1-lb. loaf of bread, were obtained from each mixing. Fermentation was carried out in closed containers in a constant-temperature room held at 28° C.; kneading intervals followed 1 hour and 35 minutes, 40 minutes, and 20 minutes. The dough was proofed at 35° C. and 92% humidity for 60 minutes. Bread was baked in a 4-shelf, reel oven, thermostatically regulated to 204° C. for 30 minutes. The loaf volumes were obtained on the day following the baking, and the grain, texture, and crumb characteristics were noted. Since these characteristics could not be measured with reliable accuracy, only loaf-volume measurements are presented for comparison of the baking quality of the milk solids used in the bread formulas.

Except for the amount of water added, all conditions of bread manufacture and bread formula ingredients were kept constant, and no variations were made to bring about conditions which might yield more satisfactory bread with milk samples of inferior baking quality. Extra water, equal to the weight of the skimmilk solids, was added to doughs containing skimmilk that had been held at 82° C. for 30 minutes. This extra water was not necessary in doughs containing skimmilk that had been held at 63° C. for 30 minutes. At each baking a separate dough was included that contained no milk solids but was identical in all other

TABLE 1

*Influence of storage time on loaf volume obtained with nonfat milk solids prepared and stored under various conditions (Four-loaf average expressed in ml.)*

| Months in storage | Water control | Low-heat powder (62° C/30′) | High-heat powder (82° C/30′) | Low-heat froz. cond. (4:1/−17° C.) | High-heat froz. cond. | | |
|---|---|---|---|---|---|---|---|
| | | | | | (4:1/−17° C.) | (5:1/−17° C.) | (5:1/−27° C.) |
| 0 | 2367[a] | 2375 | 2419 | 2275 | 2506 | 2500 | 2500 |
| 2 | 2281 | 2425 | 2481 | 2306 | 2525 | 2419 | 2463[a] |
| 3 | 2413[a] | 2356 | 2544 | 2225[a] | 2494 | 2525 | 2531 |
| 4 | 2512[a] | 2312[a] | 2512[a] | 2267[a] | 2475[a] | 2512[a] | 2512[a] |
| 7 | 2463 | 2463 | 2469 | 2169 | 2488 | 2369 | 2450 |
| 9 | 2393 | 2275 | 2450 | 2169 | 2350 | 2413 | 2413 |
| 12 | 2538 | 2325 | 2544 | 2138 | 2581 | 2494 | 2569 |
| | Loaf volume average over one-year storage | | | | | | |
| | 2422 | 2365 | 2502 | 2217 | 2489 | 2458 | 2492 |
| | Variations in loaf volume averages from total average | | | | | | |
| 0 | −55 | +10 | (−83) | +58 | +17 | +42 | +8 |
| 2 | (−141) | +60 | −21 | (+89) | +36 | −39 | −29 |
| 3 | −9 | −9 | +42 | +8 | +5 | +67 | +39 |
| 4 | (+90) | −53 | +9 | +50 | −14 | +54 | +20 |
| 7 | +41 | (+98) | +66 | −48 | −1 | (−89) | −42 |
| 9 | +49 | (−90) | −53 | −48 | (−139) | −45 | (−79) |
| 12 | (+116) | −40 | +41 | (−79) | (+92) | +36 | (+77) |

[a] Two-loaf average.

respects to the other doughs baked at that time. This so-called "water dough" was carried through the standard procedure, and the loaf volume was obtained in order to observe any changes in baking which might be due to causes other than the nonfat milk solids.

The measurement of the baking quality of the various milk samples was limited in this investigation to measurement of loaf volume of the bread produced when the milk was included in the bread formula at the level of 6 parts milk solids per 100 parts flour. However, the properties of the dough during the bread production and the characteristics of the bread crumb are equally important. Throughout the duration of the experiment, the dough characteristics, as well as the grain and texture of the bread crumb, were constant, depending upon the treatment of the milk samples. Without exception, the low-heat–treated, frozen condensed skimmilk and its corresponding dried skimmilk produced dough of inferior quality in the sense that it was stiff, nonpliable, putty-like, and required long mixing; the crumb of this bread invariably was harsh-feeling and was comprised of irregularly shaped cells with thick walls. When high-heat–treated milk samples, either frozen or powdered, were used in the bread formula, the reverse characteristics were always noted.

In Table 1 are shown the loaf volume averages obtained when fresh and stored skimmilk samples were included in white pan bread at 6% level of milk solids based on flour weight. Also included in Table 1 are the grand average loaf volumes (calculated from each original loaf volume measurement) for a given milk over the entire duration of the experiment and the differences between this voume and the averages for specific storage periods. The standard error of a single determination in this series was approximately 75 ml., and variations in loaf volume average above this figure have been indicated by parentheses. It is seen that there is no recognized trend for any sample to become progressively inferior or superior to the average value of that variable for the entire experiment. This is interpreted to mean that none of the variously prepared and stored skimmilk products changed materially over the period of the experiment in their baking quality as measured by loaf volume.

Several interesting relationships can be recognized from Table 1. High-heat, nonfat, dried milk solids included in bread formulas not only produced substantially larger loaf volumes than did the low-heat–treated dried milk solids (a fact which has been recognized for some time) but also produced slightly larger loaf volumes than identical milk solids preserved in a frozen state under any of the conditions of temperature or concentration that were used. It is also shown that low-heat–treated dried skimmilk solids invariably produced larger loaf volumes than did identically treated nonfat milk solids preserved in concentrated frozen state at –17° C. during a year, but not as large as any of the loaves that contained solids from high-heat frozen condensed skimmilk.

## SUMMARY

Skimmilks condensed to 4:1 and 5:1 became extremely unstable when stored for long periods at –17° and at –27° C. These milks developed high viscosity,

poor texture, and undesirable appearance. The high-heat treatment caused higher viscosities in otherwise similar skimmilks. The lower (–27° C.) storage temperature delayed the rate of denaturation of the condensed skimmilk. These milks were entirely unsatisfactory from the beverage standpoint.

The temperature of storage caused no improvement or impairment in baking quality as determined by dough characteristics, texture of crumb, and loaf volume of bread. High-heat–treated (82° C. for 30 minutes) skimmilk solids, preserved in a frozen or dried state, produced larger loaf volumes than corresponding low-heat (62° C. for 30 minutes) skimmilk solids. Heat treatment was the primary factor in determining baking quality. The slightly greater loaf volumes obtained with skimmilk solids stored in a dried instead of in a frozen condensed state indicate some advantage in preserving skimmilk solids in this form.

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